Basic Research

Science and Public Policy (Steelman report)
Part One—Science for the Nation, IV. A National Science Program

Basic research traditionally has been conducted in the colleges and universities. While industry engages in some basic research and the Government laboratories conduct a somewhat greater amount, the proportions in both instances are small. The principal function of the colleges and universities is to promote the progress of learning and they must be the primary means through which any expanded program of basic research is carried out. There are several reasons for this.

First, the scientific method, being based upon experiment, requires research for the teaching of science. Fully trained scientists can be produced only through practicing research.

Second, basic research is so broad in its application and so indirectly related to any industrial process, or in fact to any particular industry, that it is not profitable for private enterprise to engage in extensive basic research. Industries do sometimes support it through fellowships and other grants to universities, but the sums involved are not large.

Third, research, while carried out by individuals, has always been a cooperative venture. Scientists have exchanged information and collaborated with each other in the performance of research; and science progresses characteristically through a combination of knowledge from many different sources. Research thrives in situations where scientists with many diverse interests and fields of knowledge can be brought together in an exchange of both knowledge and ideas. Thus the universities, which foster all branches of knowledge, are ideal breeding grounds for basic research. (Steelman 1947, 29.)

The next section discusses trends in the employment, demographic characteristics, and activities of academic doctoral scientists and engineers. The discussion of employment trends focuses on full-time faculty, postdoctorates, and other positions. Differences are examined between the Nation's largest research universities and other academic institutions, as are shifts in the faculty age structure. The involvement of women, underrepresented minorities, and Asians and Pacific Islanders is also examined. Attention is given to participation in research by academic doctoral scientists and engineers, the relative balance between teaching and research, and the Federal support they report for their research. Selected demographic characteristics of recent doctorate-holders entering academic employment are examined.

The third section looks at the relationships between research and graduate education. It covers overall trends in graduate support and patterns of support in different types of institutions, and compares support patterns for those who complete an S&E doctorate with the full population of graduate students. The role of graduate research assistantships is examined in some detail, including the sources of support for research assistants and the spreading incidence of research assistantship (RA) support to a growing number of academic institutions.

The chapter's final section deals with two research outputs: scientific and technical articles in a set of journals covered by the Science Citation Index (SCI), and patents issued to U.S. universities. (A third major output of academic R&D, educated and trained personnel, is discussed in the preceding section of this chapter and in chapter 4.) The section specifically looks at the output volume of research (article counts), collaboration in the conduct of research (joint authorship), use in subsequent scientific activity (citation patterns), and use beyond science (citations to the literature on patent applications). It concludes with a discussion of academic patenting and some returns to academic institutions from their patents and licenses.

Financial Resources for Academic R&D[1]

Academic R&D is a significant part of the national R&D enterprise. Enabling U.S. academic researchers to carry out world-class research requires adequate financial support as well as excellent research facilities and high-quality research equipment. Consequently, assessing how well the academic R&D sector is doing, the challenges it faces, and how it is responding to those challenges requires data and information relating to a number of important issues that relate to the financing of academic R&D. Among these issues are the level and stability of overall funding; the sources of funding and changes in their relative importance; the distribution of funding among the different R&D activities (basic research, applied research, and development); the balance of funding among science and engineering fields and subfields or fine fields; the distribution of funding among and the extent of participation of various types of academic R&D performers; the changing role of the Federal Government as a supporter of academic R&D and the particular roles of the major Federal agencies funding this sector; and the state of the physical infrastructure—research facilities and equipment—that is a necessary input to the sector's success. This section focuses on providing data on these aspects of the academic R&D enterprise which individually and in combination influence its evolution.

[1]Data in this section come from several different National Science Foundation (NSF) surveys that do not always use comparable definitions or methodologies. NSF's three main surveys involving academic R&D are the (1) Survey of Federal Funds for Research and Development; (2) Survey of Federal Science and Engineering Support to Universities, Colleges, and Nonprofit Institutions; and (3) Survey of Research and Development Expenditures at Universities and Colleges. The results from this last survey are based on data obtained directly from universities and colleges; the former two surveys collect data from Federal agencies. For descriptions of the methodologies of these and other NSF surveys, see NSF (1995b and 1995c).Federally Funded Research and Development Centers associated with universities are tallied separately and are examined in greater detail in chapter 2.

Academic R&D in the National R&D Enterprise[2]

The continuing importance of academe to the Nation's overall R&D effort is still recognized today, especially its contribution to the generation of new knowledge through basic research.

In 1998, an estimated $26.3 billion, or $23.4 billion in constant 1992 dollars, was spent on R&D at U.S. academic institutions.[3] This was the 24th consecutive year in which constant dollar spending increased from the previous year. Academia's role as an R&D performer has increased fairly steadily during the past half-century, rising from about 5 percent of all R&D performed in the country in 1953 to almost 12 percent in 1998. (See figure 6-1.) However, since 1994, the sector's performance share has dipped slightly from its high of almost 13 percent (see "Growth" section below). For a description of the role of universities in national R&D expenditures in the first part of the 20th century, see chapter 1, "Science and Technology in Times of Transition: the 1940s and 1990s."

Character of Work

Academic R&D activities are concentrated at the research (basic and applied) end of the R&D spectrum and do not include much development activity.[4] Of 1998 academic R&D expenditures, an estimated 93 percent went for research (69 percent for basic and 24 percent for applied) and 7 percent for development. (See figure 6-2.) From a national research—as opposed to national R&D—perspective, academic institutions accounted for an estimated 27 percent of the U.S. total in 1998. The academic share of research almost doubled, from about 14 percent of the U.S. total in the 1950s to around 26 percent in the first half of the 1970s. It has since fluctuated between 23 and 30 percent. And, in terms of basic research alone, the academic sector is the country's largest performer, currently accounting for an estimated 48 percent of the national total. Between 1953 and 1972, the academic sector's basic research performance grew steadily, increasing from about one-quarter to just over one-half of the national total. It has since fluctuated between 45 and 51 percent of the national total. (See figure 6-1.)

Growth

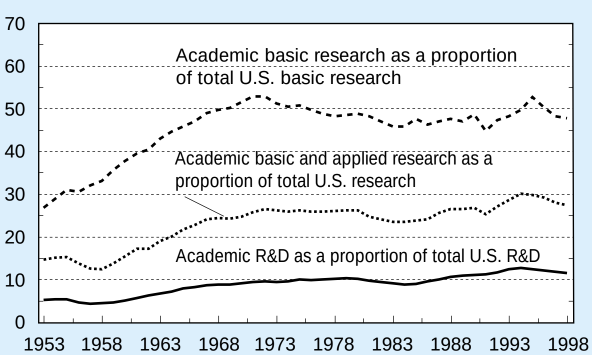
Over the long term (between 1953 and 1998), average annual R&D growth (in constant 1992 dollars) has been stronger for the academic sector than for any other R&D-performing sector—6.5 percent, compared to about 5.7 per-

[2]For more information on national R&D expenditures, see "Economic Measures of R&D" in chapter 2.

[3]For the purposes of this discussion, academic institutions generally comprise institutions of higher education that grant doctorates in science or engineering and/or spend at least $50,000 for separately budgeted R&D. In addition, all Historically Black Colleges and Universities (HBCUs) with R&D programs are included, regardless of the level of R&D.

[4]Notwithstanding this delineation, the term "R&D"—rather than just "research"—is used throughout this discussion unless otherwise indicated, since much of the data collected on academic R&D does not differentiate between "R" and "D." Moreover, it is often difficult to make clear distinctions among basic research, applied research, and development. For the definitions used in NSF resource surveys, see chapter 2.

Figure 6-1.
Academic R&D, research, and basic research as a proportion of U.S. totals: 1953–98

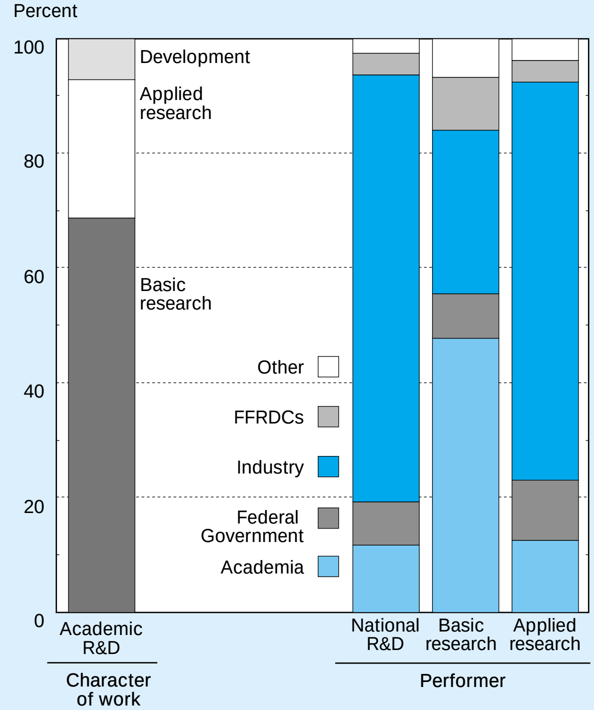


NOTE: Data for 1998 are preliminary.

See appendix tables 2-3, 2-7, and 2-11.

Science & Engineering Indicators – 2000

Figure 6-2.
Academic R&D expenditures by character of work and national R&D expenditures by performer and character of work: 1998



FFRDC = Federally Funded Research and Development Center

NOTE: Data are preliminary.

See appendix tables 2-3, 2-7, 2-11, and 6-1.

Science & Engineering Indicators – 2000

cent for federally funded research and development centers (FFRDCs), 5.2 percent for other nonprofit laboratories, 4.8 percent for industrial laboratories, and 2.5 percent growth for Federal laboratories. (See appendix table 2-4 for time series data by R&D-performing sector.) This long-term trend has held for more recent times as well—through the 1980s and the early part of the 1990s—although average annual growth was higher for all R&D-performing sectors between 1953 and 1980 than it has been since 1980. However, beginning in 1994 growth of R&D performed in industry (an estimated 7.6 percent annually) started to outpace growth of academically performed R&D (an estimated 3.2 percent annually). As a proportion of gross domestic product (GDP), academic R&D rose from 0.07 to 0.31 percent between 1953 and 1998, a more than fourfold increase. (See appendix table 2-1 for GDP time series.)

University R&D Expenditures

Science and Public Policy (Steelman report)
Part One—Science for the Nation, IV.
A National Science Program

There is every reason to anticipate a doubling of research and development expenditures by industry in the next decade, in view of the long term trends and the increasing dependence of industry upon research and development. But there is little likelihood of any considerable expansion of university expenditures out of their present income sources. Endowment income has sharply declined over the last 15 years and there is little likelihood of any considerable rise in interest rates in the future. Moreover, the large fortunes which were the source of new endowment funds are now considerably limited by taxation. So far as State-supported institutions are concerned, the long-run financial position of many states makes large increases in university support unlikely. A similar situation confronts the private foundations, which are not, in any event, of great significance in the over-all financial picture. The foundations have contributed enormously to the extension of knowledge and to the support of basic research, but their expenditures have been small in terms of the total budget. It is not likely that their share will expand in the future. (Steelman 1947, 26-7.)

Major Funding Sources

The continued reliance of the academic sector on a variety of funding sources for support of its R&D activities requires continuous monitoring of the contributions of those sources.

The Federal Government continues to provide the majority of funds for academic R&D. In 1998, it accounted for an estimated 59 percent of the funding for R&D performed in academic institutions. After increasing from 55 percent in 1953 to its peak of just over 73 percent in 1966, the Federal support share declined fairly steadily until the early 1990s. (See figure 6-3.) Since 1992, it has fluctuated between 59 and 60 percent. The Federal sector primarily supports basic research—72 percent of its 1998 funding went to basic research versus 20 percent to applied. Non-Federal sources also concentrate on basic research, but provide a larger share of their support than the Federal sector for applied research (64 percent for basic and 30 percent for applied research). (See appendix table 6-1.) As a consequence of this differential emphasis, 62 percent of the basic research performed at universities and colleges is supported by the Federal Government, while only 49 percent of the applied research is so supported.

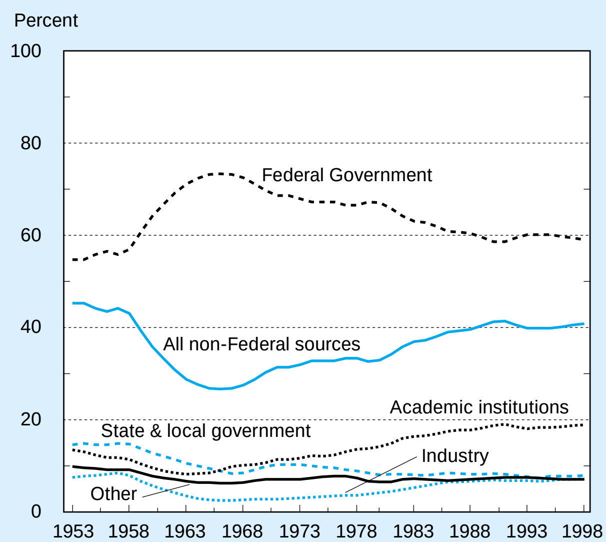
Federal support of academic R&D is discussed in detail later in this section; the following summarizes the contributions of other sectors to academic R&D.[5]

- **Institutional funds.**[6] In 1998, institutional funds from universities and colleges constituted the second largest source of academic R&D funding, accounting for an estimated 19 percent. The share of support represented by this source has been increasing fairly steadily since the early 1960s, save for a brief downturn in the early 1990s. Institutional

[5]The academic R&D funding reported here includes only separately budgeted R&D and institutions' estimates of unreimbursed indirect costs associated with externally funded R&D projects, including mandatory and voluntary cost sharing. It does not include departmental research, and thus will exclude funds—notably for faculty salaries—in cases where research activities are not separately budgeted.

[6]Institutional funds are separately budgeted funds that an academic institution spends on R&D from unrestricted sources, unreimbursed indirect costs associated with externally funded R&D projects, and mandatory and voluntary cost sharing on Federal and other grants. As indicated above, departmental research that is not separately budgeted is not included.

Figure 6-3.
Sources of academic R&D funding: 1953–98



NOTE: Data for 1998 are preliminary.

See appendix table 6-2. *Science & Engineering Indicators – 2000*

R&D funds may be derived from (1) general-purpose state or local government appropriations, particularly for public institutions; (2) general-purpose grants from industry, foundations, or other outside sources; (3) tuition and fees; (4) endowment income; and (5) gifts that are not restricted by the donor to conduct research. Other potential sources of institutional funds are income from patents or licenses and income from patient care revenues. (See "Academic Patenting: Patent Awards, Licenses, Startups, and Revenue" later in this chapter for a discussion of patent and licensing income.)

- **State and local government funds.** In 1998, the share of academic R&D funding provided by state and local governments was an estimated 8 percent. State and local governments played a larger role during the early 1950s, when they provided about 15 percent of the funding. Their relative role began to decline thereafter except for a brief upturn between 1968 and 1973. Their share of academic R&D funding has fluctuated between 7 and 8 percent since 1980. This share, however, reflects only funds directly targeted to academic R&D activities by the state and local governments and does not include general-purpose state or local government appropriations that academic institutions designate and use for separately budgeted research or to cover unreimbursed indirect costs.[7] Consequently, the actual contribution of state and local governments to academic R&D is understated, particularly for public institutions.

- **Industry funds.** In 1998, industry provided an estimated 7 percent of academic R&D funding. The funds provided for academic R&D by the industrial sector grew faster than funding from any other source during the past three decades, although industrial support still accounts for one of the smallest shares of funding. During the 1950s, industry's share was actually larger than it is currently, peaking at 8.4 percent in 1957. After reaching this peak, the industrial share steadily declined, reaching its low of 2.5 percent in 1966. Industry then began to increase its share from slightly below 3 percent in 1970, to about 4 percent in 1980 and about 7 percent in 1990, where it has since remained. Industry's contribution to academia represented an estimated 1.3 percent of all industry-funded R&D in 1998, compared to 0.9 percent in 1980, 0.6 percent in 1970, and 1.1 percent in 1958. (See appendix tables 2-4 and 2-5 for time series data on industry-funded R&D.) Thus, although increasing recently, industrial funding of academic R&D has never been a major component of industry-funded R&D.

- **Other sources of funds.** In 1998, other sources of support accounted for 7 percent of academic R&D funding. This share has stayed fairly constant at about this level during the past three decades after declining from its peak of 10 percent in 1953. These sources include grants for R&D from nonprofit organizations and voluntary health agencies and gifts from private individuals that are restricted by the donor to conduct research, as well as all other sources restricted to research purposes not included in the other categories.

[7]This follows international standards of reporting where funds are assigned to the entity determining how they are to be used rather than to the one necessarily providing the funds.

Funding by Institution Type

Although public and private universities rely on the same funding sources for their academic R&D, the relative importance of those sources differs substantially for these two types of institutions. (See appendix table 6-3.) For all *public* academic institutions combined, just over 10 percent of R&D funding in 1997—the most recent year for which data are available—came from state and local funds, about 23 percent from institutional funds, and about 53 percent from the Federal Government. *Private* academic institutions received a much smaller portion of their funds from state and local governments (about 2 percent) and from institutional sources (10 percent), and a much larger share from the Federal Government (72 percent). The large difference in the role of institutional funds between public and private institutions is most likely due to a substantial amount of general-purpose state and local government funds received by the former that these institutions decide to use for R&D (although data on such breakdowns are not collected). Both public and private institutions received approximately 7 percent of their respective R&D support from industry in 1997. Over the past two decades, the Federal share of support has declined, and the industry and institutional shares have increased, for both public and private institutions.

Distribution of R&D Funds Across Academic Institutions

The nature of the distribution of R&D funds across academic institutions has been and continues to be a matter of interest to those concerned with the academic R&D enterprise. Most academic R&D is now, and has been historically, concentrated in relatively few of the 3,600 higher education institutions in the United States.[8] In fact, if all such institutions were ranked by their 1997 R&D expenditures, the top 200 institutions would account for about 95 percent of R&D expenditures. In 1997 (see appendix table 6-4[9]):

[8]The Carnegie Foundation for the Advancement of Teaching classified about 3,600 degree-granting institutions as higher education institutions in 1994. (See chapter 4 sidebar, "Carnegie Classification of Institutions," for a brief description of the Carnegie categories.) These higher education institutions include four-year colleges and universities, two-year community and junior colleges, and specialized schools such as medical and law schools. Not included in this classification scheme are more than 7,000 other postsecondary institutions (secretarial schools, auto repair schools, and so forth.).

[9]The Johns Hopkins University and the Applied Physics Laboratory (APL) at the Johns Hopkins University are reported separately in appendix table 6-4. Although not officially classified as an FFRDC, APL essentially functions as one. Separate reporting therefore provides a better measure of the distribution of academic R&D dollars and the ranking of individual institutions.

Other Assistance

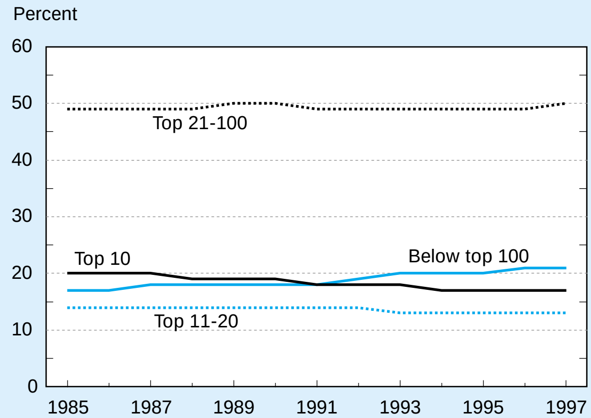
Science and Public Policy (Steelman report)
Part One—Science for the Nation, IV.
A National Science Program

While the support of basic research through the National Science Foundation is of the utmost importance, it is only one of several elements in our total national science program. Moreover, it is only one element in our developing program of Federal support for higher education...Few persons would doubt today that we must soon develop a permanent, long-range program of Federal assistance to students and of Federal aid to education in general. Viewed in perspective, the support of basic research in the colleges and universities is part of such a program. It can achieve results only as the colleges and universities themselves are strong and only as means are found to permit able students to pursue their studies.

In such terms, it is clear that a portion of the funds expended by the National Science Foundation should be used to strengthen the weaker, but promising, colleges and universities, and thus to increase our total scientific potential. (Steelman 1947, 34.)

[For a discussion of a Federal program created to strengthen research and education in the sciences and engineering and to avoid undue concentration of such research and education, see sidebar, “EPSCoR—the Experimental Program to Stimulate Competitive Research.”]

Figure 6-4.
Share of academic R&D of top R&D universities and colleges: 1985–97



See appendix table 6-4. *Science & Engineering Indicators – 2000*

- ♦ the top 10 institutions spent 17 percent of total academic R&D funds ($4.1 billion),
- ♦ the top 20 institutions spent 30 percent ($7.3 billion),
- ♦ the top 50 spent 56 percent ($13.6 billion), and
- ♦ the top 100 spent 79 percent ($19.3 billion).

This historic concentration of academic R&D funds, however, has been diminishing somewhat over the past dozen years. (See figure 6-4.) In 1985, the top 10 institutions received about 20 percent and the top 11–20 institutions 14 percent of the funds, compared to 17 and 13 percent, respectively, in 1997. The composition of the universities in the top 20 has also fluctuated slightly over the period. There was almost no change in the share of the group of institutions ranked 21–100 during this period. The decline in the top 20 institutions’ share was matched by the increase in the share of those institutions in the group below the top 100—this group’s share increased from 17 to 21 percent of total academic R&D funds. This increased share of the Nation’s total academic R&D expenditures by those institutions ranked below the top 100 signifies a broadening of the base. See “The Spreading Institutional Base of federally Funded Academic R&D” in the “Federal Support of Academic R&D” section below for a discussion of the increase in the number of academic institutions receiving Federal support for their R&D activities over the past three decades.

Expenditures by Field and Funding Source[10]

The distribution of academic R&D funds across S&E disciplines is often the unplanned result of numerous, sometimes unrelated, decisions and therefore needs to be monitored and documented to ensure that it remains appropriately balanced.

The overwhelming share of academic R&D expenditures in 1997 went to the life sciences, which accounted for 56 percent of total academic R&D expenditures, 54 percent of Federal academic R&D expenditures, and 58 percent of non-Federal academic R&D expenditures. Within the life sciences, medical sciences accounted for 28 percent of total academic R&D expenditures and biological sciences for 17 percent.[11] The next largest block of total academic R&D expenditures was for engineering—16 percent in 1997. (See appendix table 6-5.)

The distribution of Federal and non-Federal funding of academic R&D in 1997 varied by field. (See appendix table 6-5.) For example, the Federal Government supported close to 80 percent of academic R&D expenditures in both physics and atmospheric sciences, but only 30 percent of academic R&D in political science and 29 percent in the agricultural sciences.

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[10]The data in this section are drawn from NSF’s Survey of Research and Development Expenditures at Universities and Colleges. For various methodological reasons, parallel data by field from the NSF Survey of Federal Funds for Research and Development do not necessarily match these numbers.

[11]Medical sciences includes research in fields such as pharmacy, veterinary medicine, anesthesiology, and pediatrics. Biological sciences includes research in fields such as microbiology, genetics, biometrics, and ecology. These distinctions may be blurred at times, as the boundaries between fields are often not well defined.

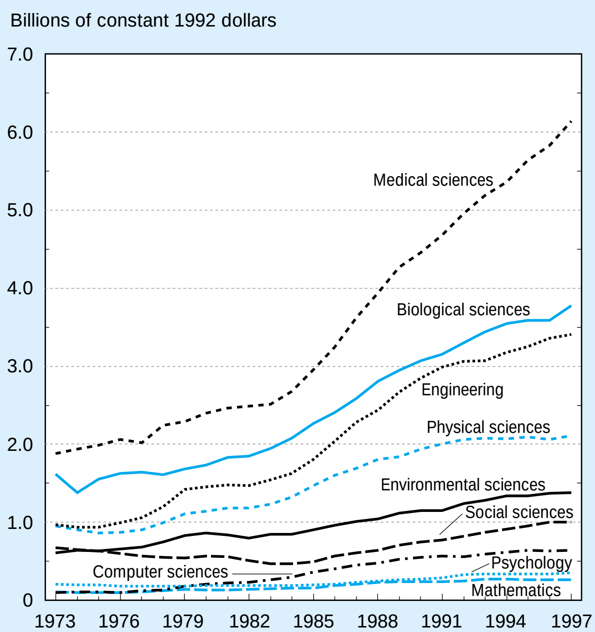
The declining Federal share in support of academic R&D is not limited to particular S&E disciplines. Rather, the federally financed fraction of support for each of the broad S&E fields was lower in 1997 than in 1973, except for the computer sciences (which was slightly higher). (See appendix table 6-6.) The most dramatic decline occurred in the social sciences—down from 57 percent in 1973 to 37 percent in 1997. The overall decline in Federal share also holds for all the reported fine S&E fields. However, most of the declines occurred in the 1980s, and most fields have not experienced declining Federal shares during the 1990s.

Although academic R&D expenditures in constant dollars for every field have increased between 1973 and 1997 (see figure 6-5 and appendix table 6-7), the R&D emphasis of the academic sector, as measured by its S&E field shares, has changed during this period.[12] (See figure 6-6.) Absolute shares of academic R&D have:

- ♦ increased for the life sciences, engineering, and computer sciences;
- ♦ remained roughly constant for mathematics; and
- ♦ declined for the social sciences, psychology, the environmental (earth, atmospheric, and oceanographic) sciences, and the physical sciences.

[12]For a more detailed discussion of these changes, see *How Has the Field Mix of Academic R&D Changed?* (NSF 1999g).

Figure 6-5.
Academic R&D expenditures, by field: 1973–97



NOTE: See appendix table 2-1 for GDP implicit price deflators used to convert current dollars to constant 1992 dollars.

See appendix table 6-7. *Science & Engineering Indicators – 2000*

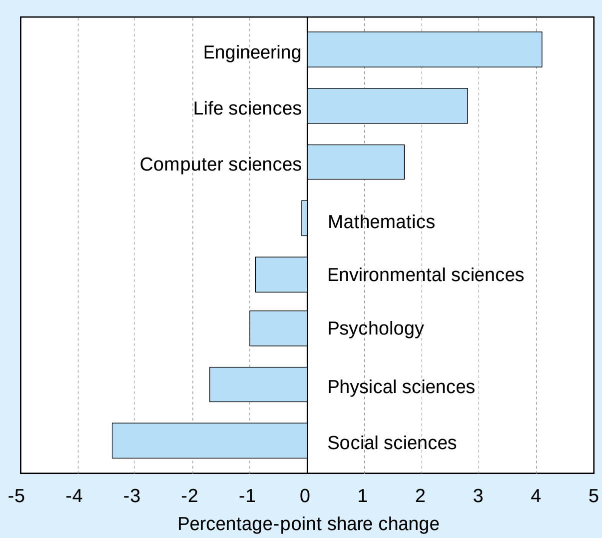
Although the proportion of the total academic R&D funds going to the life sciences' share increased by only 3 percentage points, rising from 53 to 56 percent of academic R&D between 1973 and 1997, the medical sciences' share increased by almost 6 percentage points—from 22 to 28 percent of academic R&D—during this period. The other two major components of the life sciences—agricultural sciences and biological sciences—both lost shares during the period. The engineering share increased by 4 percentage points over this period—from 12 to 16 percent of academic R&D; while the computer sciences' share increased from 1 to 3 percent of academic R&D.

The social sciences' proportion declined by more than 3 percentage points (from 8 to below 5 percent of academic R&D) between 1973 and 1997. Within the social sciences, the R&D shares for each of the three main fields—economics, political science, and sociology—declined over the period. Psychology's share declined by 1 percentage point (from 3 to 2 percent of academic R&D). The environmental sciences' share also declined by 1 percentage point (from 7 to 6 percent). Within the environmental sciences, the three major fields—atmospheric sciences, earth sciences, and oceanography—each experienced a decline in share. The physical sciences' share also declined during this period, from 11 to 10 percent. However, within the physical sciences, astronomy's share increased while the shares of both physics and chemistry declined.

Federal Support of Academic R&D

Although the Federal Government continues to provide the majority of the funding for academic R&D, its overall contribution is the combined result of decisions by a number of key

Figure 6-6.
Changes in the share of academic R&D in selected S&E fields: 1973–97



See appendix table 6-7. *Science & Engineering Indicators – 2000*

From Vannevar Bush in Science—The Endless Frontier:

One of our hopes is that after the war there will be full employment. To reach that goal the full creative and productive energies of the American people must be released. To create more jobs, we must make new and better and cheaper products. We want plenty of new, vigorous enterprises. But new products and processes are not born full-grown. They are founded on principles and new conceptions which in turn result from basic scientific research. Basic scientific research is scientific capital. Clearly, more and better scientific research is one essential to the achievement of our goal of full employment.

How do we increase this scientific capital? First, we must have plenty of men and women trained in science, for upon them depends both the creation of new knowledge and its application to practical purposes. Second, we must strengthen the centers of basic research which are principally the colleges, universities, and research institutes. These institutions provide the environment which is most conducive to the creation of new scientific knowledge and least under pressure for immediate, tangible results. With some notable exceptions, most research in industry and in Government involves application of existing scientific knowledge to practical problems. It is only the colleges, universities, and a few research institutes that devote most of their research efforts to expanding the frontiers of knowledge. (Bush 1945.)

funding agencies with differing missions.[13] Examining and documenting the funding patterns of these agencies are key to understanding both their roles and the overall government role.

Top Agency Supporters

Three agencies are responsible for most of the Federal obligations for academic R&D: the National Institutes of Health (NIH), the National Science Foundation (NSF), and the Department of Defense (DOD). (See appendix table 6-8.) Together, these agencies are estimated to have provided approximately 83 percent of total Federal financing of academic R&D in 1999, as follows:

- NIH—58 percent,
- NSF—15 percent, and
- DOD—10 percent.

An additional 12 percent of the 1999 obligations for academic R&D are estimated to be provided by the National Aeronautics and Space Administration (NASA, 5 percent); the Department of Energy (DOE, 4 percent); and the Department of Agriculture (USDA, 3 percent). Federal obligations for academic research are concentrated similarly to those for R&D. (See appendix table 6-9.) There are some differences, however, since agencies such as DOD place greater emphasis on development, while others such as NSF place greater emphasis on research.

During the 1990s, NIH's funding of academic R&D increased most rapidly, with an estimated average annual growth rate of 3.7 percent per year in constant 1992 dollars. NSF (3.2 percent) and NASA (2.4 percent) experienced the next highest rates of growth. Average annual rates of growth were negative for DOD, DOE, and USDA during this period. Between 1998 and 1999, total Federal obligations for academic R&D are estimated to increase by 5.4 percent in constant dollars. NSF (by 11 percent) and NIH (by 8 percent) are expected to have the largest increases in their academic R&D obligations in 1999.

Agency Support by Field

Federal agencies emphasize different S&E fields in their funding of academic research. Several agencies concentrate their funding in one field—the Department of Health and Human Services (HHS) and USDA focus on the life sciences, while DOE concentrates on the physical sciences. Other agencies—NSF, NASA, and DOD—have more diversified funding patterns. (See figure 6-7.) Even though an agency may place a large share of its funds in one field, it may not be a leading contributor to that field, particularly if it does not spend much on academic research. (See figure 6-8.) NSF is the lead funding agency in the physical sciences (34 percent of total funding), mathematics (66 percent), the environmental sciences (46 percent), and the social sciences (38 percent). DOD is the lead funding agency in the computer sciences (48 percent) and in engineering (39 percent). HHS is the lead funding agency in the life sciences (87 percent) and psychology (89 percent). Within fine S&E fields, other agencies take the leading role—DOE in physics (53 percent), USDA in agricultural sciences (99 percent), and NASA in astronomy (77 percent) and in both aeronautical (70 percent) and astronautical (65 percent) engineering. (See appendix table 6-11.)

The Spreading Institutional Base of Federally Funded Academic R&D

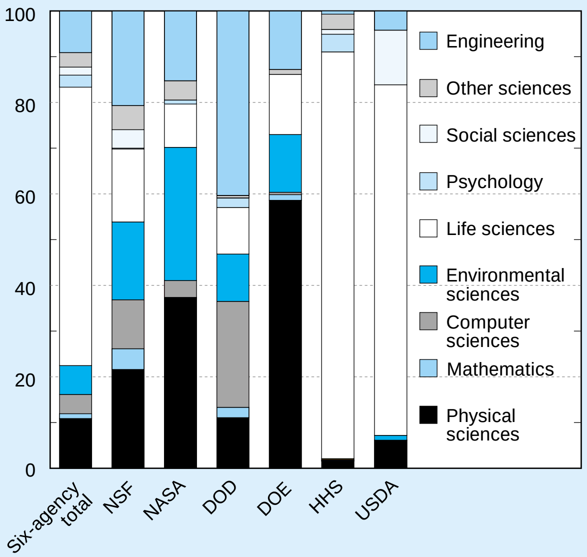
The number of academic institutions receiving Federal support for their R&D activities has increased over the past three decades.[14] Although that number has fluctuated during this time period,[15] there was an increase of almost 50 percent in the number of institutions receiving support in 1997, com-

[13]Some of the Federal R&D funds obligated to universities and colleges are the result of appropriations that Congress directs Federal agencies to award to projects that involve specific institutions. These funds are known as congressional earmarks. See Brainard and Cordes (1999) for a discussion of this subject.

[14]The data in this section are drawn from NSF's Survey of Federal Support to Universities, Colleges, and Nonprofit Institutions. The survey collects data on Federal R&D obligations to individual U.S. universities and colleges from the 15 Federal agencies that account for virtually all such obligations. For various methodological reasons, data reported in this survey do not necessarily match those reported in the Survey of Research and Development Expenditures at Universities and Colleges.

[15]The rather large decline in the number of institutions receiving Federal R&D support in the early 1980s was most likely due to the fall in Federal R&D funding for the social sciences during that period.

Figure 6-7.
Distribution of Federal agency academic research obligations, by field: FY 1997

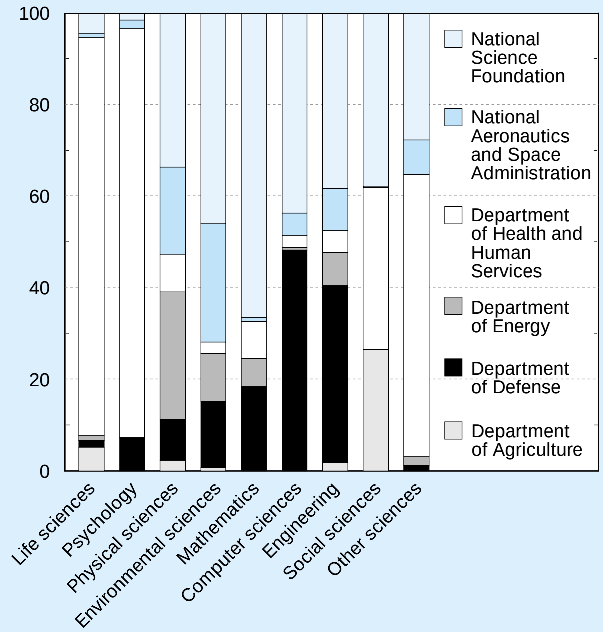


NSF = National Science Foundation; NASA = National Aeronautics and Space Administration; DOD = Department of Defense; DOE = Department of Energy; HHS = Department of Health and Human Services; USDA = Department of Agriculture

NOTE: The six agencies reported represent approximately 96 percent of Federal academic research obligations.

See appendix table 6-10. *Science & Engineering Indicators – 2000*

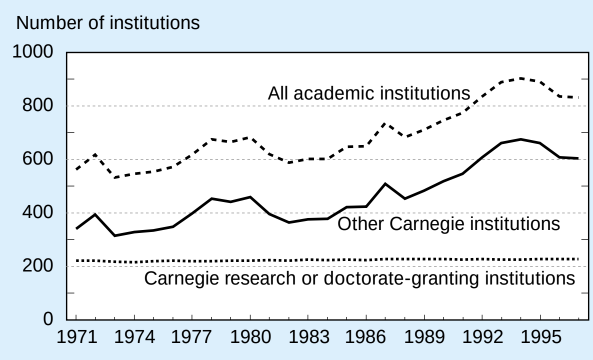
Figure 6-8.
Major agency field shares of Federal academic research obligations: FY 1997



NOTE: The six agencies reported represent approximately 96 percent of Federal academic research obligations.

See appendix table 6-11. *Science & Engineering Indicators – 2000*

Figure 6-9.
Number of academic institutions receiving Federal R&D support by selected Carnegie classification: 1971–97



NOTES: See "Carnegie Classification of Institutions" in Chapter 4 for information on the institutional categories used by the Carnegie Foundation for the Advancement of Teaching. "Other Carnegie institutions" are all institutions except Carnegie research and doctorate-granting institutions.

See appendix table 6-12. *Science & Engineering Indicators – 2000*

pared to 1971. (See figure 6-9.) Since most institutions currently designated as Carnegie research and doctorate-granting institutions were already receiving Federal support in 1971, most of the increase has occurred among the group containing comprehensive; liberal arts; two-year community, junior, and technical; and professional and other specialized schools.[16] The number of such institutions receiving Federal support just about doubled between 1971 and 1994, rising from 341 to 676. Since 1994, although the number of Carnegie research and doctorate-granting institutions receiving Federal R&D support has remained constant, there has been a rather substantial drop in the number of other institutions—from their peak of 676 to only 604 in 1997. However, most of the drop occurred in institutions receiving less than $100,000 in Federal R&D obligations. The number of other institutions receiving $100,000 or more in obligations was about 400 in both 1994 and 1997. The non-research and non-doctorate-granting institutions also received a larger share of the reported Federal obligations for R&D to universities and colleges in the 1990s than they have at any time in the past—about 13 percent between 1993 and 1997. The largest percentage this group had received before the 1990s was just under 11 percent in 1977. This increase in share is consistent with the increase in the share of academic R&D support going to institutions below the top 100 reported in the earlier section on "Distribution of R&D Funds Across Academic Institutions."

[16]See chapter 4 sidebar, "Carnegie Classification of Institutions" for a brief description of the Carnegie categories.

EPSCoR—the Experimental Program to Stimulate Competitive Research

EPSCoR, the Experimental Program to Stimulate Competitive Research, is based on the premise that universities and their science and engineering faculty and students are valuable resources that can potentially influence a state's development in the 21st century much in the same way that agricultural, industrial, and natural resources did in the 20th century.

EPSCoR originated as a response to a number of stated Federal objectives. Section 3(e) of the National Science Foundation (NSF) Act of 1950, as amended, states that "it shall be an objective of the Foundation to strengthen research and education in the sciences and engineering, including independent research by individuals, throughout the United States, and to avoid undue concentration of such research and education." Even earlier, the 1947 Steelman report, *Science and Public Policy*, in discussing the formation of NSF, stated "*it is clear that a portion of the funds expended by the National Science Foundation should be used to strengthen the weaker, but promising, colleges and universities, and thus to increase our total scientific potential*." [Emphasis added]

But EPSCoR did not officially begin at NSF until 1978, when Congress authorized NSF to conduct EPSCoR in response to broad public concerns about the extent of geographical concentration of Federal funding of R&D. Eligibility for EPSCoR participation was limited to those jurisdictions that have historically received lesser amounts of Federal R&D funding and have demonstrated a commitment to develop their research bases and to improve the quality of science and engineering research conducted at their universities and colleges.

Eighteen states and the Commonwealth of Puerto Rico currently participate in the NSF program. The states are Alabama, Arkansas, Idaho, Kansas, Kentucky, Louisiana, Maine, Mississippi, Montana, Nebraska, Nevada, North Dakota, Oklahoma, South Carolina, South Dakota, Vermont, West Virginia, and Wyoming. As part of EPSCoR, NSF actively cooperates with state leaders in government, higher education, and business to establish productive long-term partnerships capable of effecting lasting improvements to the state's academic research infrastructure and increased national R&D competitiveness.

EPSCor increases the R&D competitiveness of an eligible state through the development and utilization of the science and technology resources residing in its major research universities. It achieves its objective by (1) stimulating sustainable science and technology infrastructure improvements at the state and institutional levels that significantly increase the ability of EPSCoR researchers to compete for Federal and private sector R&D funding, and (2) accelerating the movement of EPSCoR researchers and institutions into the mainstream of Federal and private sector R&D support.

Since 1979, other Federal agencies have adopted their own EPSCoR or EPSCoR-like programs with goals similar to those of NSF. In Fiscal Year 1993, Congressional direction precipitated the formation of the EPSCoR Interagency Coordinating Committee (EICC). A Memorandum of Understanding (MOU) was signed by officials of those agencies with EPSCoR or EPSCoR-like programs agreeing to participate in the EICC. The major objective of the MOU focused on improving coordination among and between the Federal agencies in implementing EPSCoR and EPSCoR-like programs consistent with the policies of participating agencies. The agencies included: DOD, DOE, the Environmental Protection Agency (EPA), NASA, NIH, NSF, and USDA. They agreed to the following objectives:

- Coordinate Federal EPSCoR and EPSCoR-like programs to maximize the impact of Federal support while eliminating duplication in states receiving EPSCoR support from more than one agency.
- Coordinate agency objectives with state and institutional goals, where appropriate, to obtain continued non-Federal support of S&T research and training.
- Coordinate the development of criteria to assess gains in academic research quality and competitiveness and in S&T human resource development.

In 1998, the seven EICC agencies spent a total of $89 million on EPSCoR or EPSCoR-like programs, up from $82 million in 1995. (See text table 6-1.)

Text table 6-1.
EPSCoR and EPSCorR-like program budgets, by agency
(Millions of dollars)

Agency	Fiscal year 1995	1996	1997	1998	1999[a]
Total	82.0	79.1	81.7	88.5	109.7
Department of Agriculture	13.6	11.1	11.0	13.6	13.0
Department of Defense	20.0	18.6	17.0	18.0	19.0
Department of Energy	6.1	6.5	6.3	6.4	6.8
Environmental Protection Agency	1.0		2.5	2.5	2.5
National Aeronautics and Space Administration	5.0	5.0	4.6	4.6	10.0
National Institutes of Health	0.9	2.2	1.9	5.0	10.0
National Science Foundation	35.4	35.7	38.4	38.4	48.4

EPSCoR = Experimental Program to Stimulate Competitive Research

[a]Figures for 1999 are estimates or authorized amounts.

SOURCES: "EPSCoR Interagency Coordinating Committee: FY 1999," unpublished report; and selected members of the EPSCoR Interagency Coordinating Committee.

Science & Engineering Indicators – 2000

Academic R&D Facilities and Equipment[17]

Physical infrastructure for academic R&D, especially the state of research facilities and equipment and levels and sources of funding for these two key components, remains a serious concern today.

Facilities[18]

Total Space. The amount of academic S&E research space has grown continuously over the decade. Between 1988 and 1998, total academic science and engineering research space increased by almost 28 percent, from about 112 million to 143 million net assignable square feet (NASF).[19] (See appendix table 6-13.) Doctorate-granting institutions account for most of the growth in research space over this period.

There was little change in the distribution of academic research space across fields of science and engineering between 1988 and 1998. (See appendix table 6-13.) About 90 percent of current academic research space continues to be concentrated in six S&E fields:

- the biological sciences (21 percent in 1988 and 22 percent in 1998),
- the medical sciences (17 percent in both years),
- engineering (from 14 to 16 percent),
- the agricultural sciences (from 16 to 17 percent),
- the physical sciences (from 14 to 13 percent), and
- the environmental sciences (6 percent in both years).

New Construction. The total cost of new construction projects has fluctuated over time. New construction projects begun in 1996 and 1997 for academic research facilities are expected to cost $3.1 billion. (See appendix table 6-14.) New construction projects initiated between 1986 and 1997 were expected to produce over 63 million square feet of research space when completed—the equivalent of about 45 percent of estimated 1998 research space. A significant portion of newly created research space is likely to replace obsolete or inadequate space rather than actually increase existing space. This is indicated by the fact that the total amount of research space increased by 31 million NASF between 1988 and 1998, a period in which new construction activity was expected to produce almost 54 million NASF. (See appendix table 6-13.) Thirty percent of all research-performing colleges and universities started new construction projects during 1996–97.

Science and Public Policy (Steelman report)
Part One—Science for the Nation, I.
Science and the National Interest

6. That a program of Federal assistance to universities and colleges be developed in the matters of laboratory facilities and scientific equipment as an integral part of a general program of aid to education. (Steelman 1947, p. 6.)

Part One—Science for the Nation, IV.
A National Science Program

The Need for New Facilities

A national research and development program of the size we require will necessitate a considerable expansion of research facilities. The extent and nature of this expansion cannot now be estimated, for the precise problems upon which we shall be engaged a few years from now cannot even be imagined today. Nor is it possible to determine, in view of the number of mixed-purpose facilities involved and the diversity of accounting methods, just what our present investment in such facilities may be. But we can make some informed guesses on this score as a bench-mark for the future.

The situation respecting the expansion of college and university facilities is altogether different. Existing facilities are relatively less adequate here than elsewhere and require substantial expansion. Additional libraries, laboratory space and equipment are urgently needed, not only in terms of the contemplated program of basic research, but to train scientists for research and development programs in the near future. Provision must, therefore, be made for Federal aid to educational institutions for the construction of facilities and the purchase of expensive equipment. A beginning was made on this in connection with the disposal of surplus property. It must now be put on a long-run basis.

Any such program for federally-financed research facilities should be part of a broader program of aid to higher education. In many cases, the expansion of laboratories is possible only if other expansions in plant occur. The whole problem of university and college facilities is a broad and integrated one and should be handled as such. (Steelman 1947, 36.)

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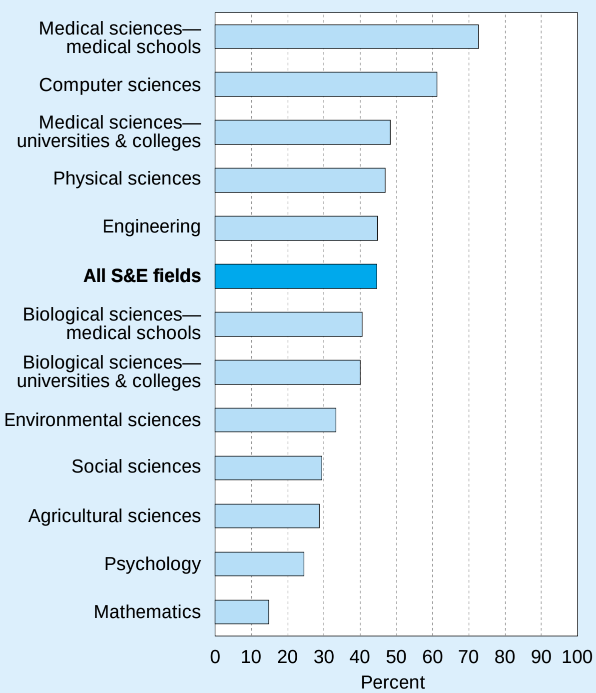
[17] Data on facilities and equipment are taken primarily from several surveys supported by NSF. Although terms are defined specifically in each survey, in general facilities expenditures (1) are classified as "capital" funds, (2) are fixed items such as buildings, (3) often cost millions of dollars, and (4) are not included within R&D expenditures as reported here. Equipment and instruments (the terms are used interchangeably) are generally movable, purchased with current funds, and included within R&D expenditures. Because the categories are not mutually exclusive, some large instrument systems could be classified as either facilities or equipment.

[18] The information in this section is derived from NSF's biennial Survey of Scientific and Engineering Research Facilities at Colleges and Universities. For more detailed data and analysis on academic S&E research facilities (for example, by institution type and control), see NSF (2000b).

[19] "Research space" here refers to the net assignable square footage (NASF) of space within facilities (buildings) in which S&E research activities take place. NASF is defined as the sum of all areas (in square feet) on all floors of a building assigned to, or available to be assigned to, an occupant for specific use, such as instruction or research. Multipurpose space within facilities, such as an office, is prorated to reflect the proportion of use devoted to research activities. NASF data for new construction and repair/renovation are reported for combined years (for example, 1987–88 data are for fiscal years 1987 and 1988). NASF data on total space are reported at the time of the survey and were not collected in 1986.

The ratio of planned new construction during the 1986–97 period to 1998 research space differs across S&E fields. More than half of the research space in the medical sciences at medical schools and in the computer sciences appears to have been built in the 1986–97 period. In contrast, less than 20 percent of the research space for mathematics appears to have been newly constructed during this period. (See figure 6-10.)

Figure 6-10.
Planned new construction between 1986 and 1997 as a percentage of 1998 research space, by S&E field



See appendix table 6-13. *Science & Engineering Indicators – 2000*

Repair and Renovation. The total cost of repair/renovation projects has also fluctuated over time. Expenditures for major repair/renovation (that is, projects costing over $100,000) of academic research facilities begun in 1996–97 are expected to reach $1.3 billion. (See appendix table 6-14.) Projects initiated between 1986 and 1997 were expected to result in the repair/renovation of almost 71 million square feet of research space.[20] (See appendix table 6-13.) Repair/renovation expenditures as a proportion of total capital expenditures (construction and repair/renovation) have increased steadily since 1990–91, rising from 22 percent of all capital project spending to 30 percent by 1996–97. More than half (52 percent) of all research-performing colleges and universities started new repair/renovation projects during 1996–97.

Sources of Funds. Academic institutions derive their funds for new construction and repair/renovation of research facilities from three major sources: institutional resources, state and local governments, and the Federal Government. Institutional resources consist of private donations, institutional funds, tax-exempt bonds, other debt sources, and other sources. (See text table 6-2.) In 1996–97:

- ♦ institutional resources accounted for 60 percent of all construction funds and 65 percent of all repair/renovation funds;
- ♦ state and local governments accounted for 31 percent of all construction funds and 26 percent of all repair/renovation funds; and
- ♦ the Federal Government directly accounted for only 9 percent of all construction funds and 9 percent of all repair/renovation funds.[21]

Public and private institutions draw upon substantially different sources to fund the construction and repair/renovation of research space. The relative distribution of construction funds between institutional types is as follows:

- ♦ Institutional resources accounted for 43 percent of all construction funds at public institutions and 91 percent at private institutions.
- ♦ State and local governments accounted for 47 percent of all construction funds at public institutions and 2 percent at private institutions.
- ♦ The Federal Government accounted for 10 percent of all construction funds at public institutions and 6 percent at private institutions.

The relative distribution of repair/renovation funds between institution types is as follows:

- ♦ Institutional resources accounted for 40 percent of all repair/renovation funds at public institutions and 91 percent at private institutions.
- ♦ State and local governments accounted for 49 percent of all repair/renovation funds at public institutions and 2 percent at private institutions.
- ♦ The Federal Government accounted for 11 percent of all repair/renovation funds at public institutions and 7 percent at private institutions.

Adequacy and Condition. Of those institutions reporting research space in a field, at least half reported inadequate amounts of space in every identifiable S&E field except math-

[20]It is difficult to report repaired/renovated space in terms of a percentage of existing research space. As collected, the data do not differentiate between repair and renovation, nor do they provide an actual count of unique square footage that has been repaired or renovated. Thus, any proportional presentation might include double or triple counts, since the same space could be repaired (especially) or renovated several times.

[21]Some additional Federal funding comes through overhead on grants and/or contracts from the Federal Government. These indirect cost payments are used to defray the overhead costs of conducting federally funded research and are counted as institutional funding. A recent memo (Jankowski 1999) indicates that about 6 to 7 percent of indirect cost payments are a reimbursement for depreciation and use of R&D facilities and equipment.

ematics, where 44 percent of the institutions reporting indicated that the amount of research space was inadequate.[22] (See text table 6-3.) In some S&E fields, a larger percentage of academic institutions rate their research space as inadequate than in others. At least 60 percent of all institutions reported that their research space was inadequate in each of the following seven S&E fields: the biological sciences in medical schools (70 percent); the medical sciences in medical schools (67 percent); the biological sciences outside of medical schools (64 percent); the physical sciences (64 percent); the earth, atmospheric, and ocean sciences (62 percent); the social sciences (61 percent); and engineering (60 percent).

[22]Adequate space is defined as the space in the field being sufficient to support all the needs of the current S&E research program commitments in the field. Inadequate amount of space is defined as space in the field insufficient to support the needs of the current S&E research program commitments in the field or nonexistent but needed.

Text table 6-2.
Funds for new construction and repair/renovation of S&E research space, by type of institution and funding source: 1996–97
(Millions of dollars)

Institution type and funding source	New construction and repair/renovation	New construction	Repair/ renovation
Total, all institutions	4,435	3,110	1,325
Federal Government	392	271	121
State and local government	1,305	967	338
Institutional sources	2,739	1,873	866
Total, public institutions	2,657	1,988	669
Federal Government	273	201	72
State and local government	1,268	940	328
Institutional sources	1,116	847	269
Total, private institutions	1,776	1,121	655
Federal Government	118	70	48
State and local government	36	26	10
Institutional sources	1,622	1,025	597

NOTE: Details may not add to totals because of rounding.

SOURCE: National Science Foundation, Division of Science Resources Studies (NSF/SRS), *Scientific and Engineering Research Facilities at Universities and Colleges: 1998*, in press (Arlington, VA: 2000).

Science & Engineering Indicators – 2000

Text table 6-3.
Adequacy of the amount of S&E research space, by field: 1998

Field	Total number of institutions	Percentage of institutions reporting that their armount of space is: Adequate	Inadequate
Physical sciences	556	36	64
Mathematical sciences	416	56	44
Computer sciences	395	44	56
Environmental sciences	365	38	62
Agricultural sciences	108	45	55
Biological sciences—universities and colleges	569	36	64
Biological sciences—medical schools	127	30	70
Medical sciences—universities and colleges	280	46	54
Medical sciences—medical schools	127	33	67
Psychology	474	49	51
Social sciences	428	39	61
Other sciences	149	56	44
Engineering	290	40	60

SOURCE: National Science Foundation, Division of Science Resources Studies (NSF/SRS), *Scientific and Engineering Research Facilities at Universities and Colleges: 1998,* in press (Arlington, VA: 2000).

Science & Engineering Indicators – 2000

Survey respondents are asked to rate the condition of their space. Almost 40 percent of S&E research space was rated as "suitable for the most scientifically competitive research." However, 18 percent of the research space was designated as needing major repair/renovation, and an additional 5 percent as needing replacement. The condition of this space differs across S&E fields. Fields with the greatest area of research space needing major repair/renovation or replacement include: the agricultural sciences (7.5 million NASF); the biological sciences outside medical schools (4.8 million NASF); the medical sciences in medical schools (4.6 million NASF); engineering (4.3 million NASF); and the physical sciences (3.9 million NASF). Fields with the largest proportion of research space needing major repair/renovation or replacement include the agricultural sciences (30 percent), and the environmental sciences, the biological sciences outside medical schools, the medical sciences in medical schools, and the medical sciences outside of medical schools (each with about 25 percent). (See text table 6-4 and appendix table 6-13.)

Unmet Needs. Determining what universities and colleges need with regard to S&E research space is a complex matter. In order to attempt to measure "real" as opposed to "speculative" needs, respondents to the survey were asked to report whether an approved institutional plan existed that included any deferred space needing new construction or repair/renovation.[23] Respondents were then asked to estimate, for each S&E field, the costs of such construction and repair/renovation projects and, separately, the costs for similar projects not included in an approved institutional plan.

In 1998, 54 percent of the institutions reported that they had to defer needed S&E construction or repair/renovation projects that would support their current research program commitments because of insufficient funds. The vast majority of institutions that had deferred projects (87 percent) had included at least some of these projects in an approved institutional plan. The total estimated cost for deferred S&E construction and repair/renovation projects (both in and not in an institutional plan) was $11.4 billion in 1998. Deferred construction projects accounted for 61 percent of this cost and deferred repair/renovation projects for the other 39 percent.

Deferred construction costs exceeded $1 billion in each of three fields. Institutions reported deferred repair/renovation costs in excess of $500 million in the same three fields. These fields and the deferred costs are: the physical sciences ($1.6 billion construction, $0.9 billion repair/renovation); the biological sciences outside medical schools ($1.2 billion construction, $0.9 billion repair/renovation); and engineering ($1.0 billion construction, $0.7 billion repair/renovation). (See appendix table 6-15.)

Equipment

Expenditures.[24] In 1997, just under $1.3 billion in current fund expenditures were spent for academic research equipment. About 80 percent of these expenditures were con-

[23]Four criteria are used to define deferred space in a survey cycle: (1) the space must be necessary to meet the critical needs of current faculty or programs, (2) construction must not have been scheduled to begin during the two fiscal years being covered by the survey, (3) construction must not have funding set aside for it, and (4) the space must not be for developing new programs or expanding the number of faculty.

[24]Data used here are from the NSF Survey of R&D Expenditures at Universities and Colleges; they are limited to current funds expenditures for research equipment and do not include funds for instructional equipment. Current funds—as opposed to capital funds—are those in the yearly operating budget for ongoing activities. Generally, academic institutions keep separate accounts for current and capital funds.

Text table 6-4.
Condition of academic science and engineering research facilities by field: 1998
(Percentages of S&E research space)

Field	Suitable for use in most scientifically sophisticated research	Requires limited repair/renovation to be used effectively	Requires major repair/renovation to be used effectively	Requires replacement
All science & engineering	39.0	38.0	18.0	5.0
Physical sciences	36.2	42.3	16.5	4.9
Mathematical sciences	44.3	41.4	11.5	2.9
Computer sciences	44.1	40.0	10.8	5.0
Environmental sciences	33.5	41.0	17.5	8.0
Agricultural sciences	32.9	36.8	23.8	6.5
Biological sciences—universities and colleges	39.6	35.5	19.6	5.3
Biological sciences—medical schools	49.3	34.6	14.1	2.0
Medical sciences—universities and colleges	31.7	43.0	20.9	4.4
Medical sciences—medical schools	43.2	31.4	19.9	5.6
Psychology	40.5	41.0	16.3	2.2
Social sciences	38.8	45.2	14.5	1.5
Engineering	41.2	39.9	14.9	3.9

SOURCE: National Science Foundation, Division of Science Resources Studies (NSF/SRS), *Scientific and Engineering Research Facilities at Universities and Colleges: 1998*, in press (Arlington, VA: 2000).

Science & Engineering Indicators – 2000

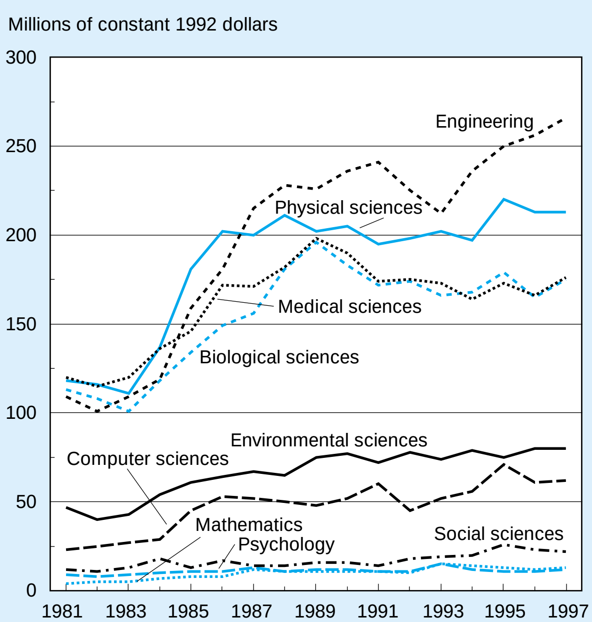
centrated in three fields: the life sciences (37 percent), engineering (23 percent), and the physical sciences (19 percent). (See figure 6-11.)

Current fund expenditures for academic research equipment grew at an average annual rate of 3.8 percent (in constant 1992 dollars) between 1981 and 1997. However, average annual growth was much higher during the 1980s (6.2 percent) than it was during the 1990s (0.7 percent). There were variations in growth patterns during this period among S&E fields. For example, equipment expenditures for mathematics (7.8 percent), the computer sciences (6.4 percent), and engineering (5.7 percent) grew more rapidly during the 1981–97 period than did those for the life sciences (2.2 percent) and psychology (2 percent). (See appendix table 6-16.)

Federal Funding. Federal funds for research equipment are generally received either as part of research grants—thus enabling the research to be performed—or as separate equipment grants, depending on the funding policies of the particular Federal agencies involved. The importance of Federal funding for research equipment varies by field. In 1997, the social sciences received slightly less than 40 percent of their research equipment funds from the Federal Government; in contrast, Federal support accounted for over 60 percent of equipment funding in the physical sciences, computer sciences, environmental sciences, and psychology.

The share of research equipment expenditures funded by the Federal Government declined from 63 percent to 59 percent between 1981 and 1997, although not steadily. This overall pattern masks different trends in individual S&E fields. For example, the share funded by the Federal Government actually rose during this period for both the computer and the environmental sciences. (See appendix table 6-17.)

Figure 6-11.
Current fund expenditures for research equipment at academic institutions, by field: 1981–97



NOTE: See appendix table 2-1 for GDP implicit price deflators used to convert current dollars to constant 1992 dollars.

See appendix table 6-16. *Science & Engineering Indicators – 2000*

R&D Equipment Intensity. R&D equipment intensity is the percentage of total annual R&D expenditures from current funds devoted to research equipment. This proportion was lower in 1997 (5 percent) than it was in 1981 (6 percent) and at its peak in 1986 (7 percent). (See appendix table 6-18.) R&D equipment intensity varies across S&E fields. It tends to be higher in the physical sciences and the computer sciences (both about 10 percent in 1997) and engineering (8 percent); and lower in the social sciences (2 percent), psychology (3 percent), and the life sciences (4 percent). For the social sciences and psychology, these differences may reflect the use of less equipment and/or less expensive equipment. For the life sciences, the lower R&D equipment intensity is more likely to reflect use of equipment that is too expensive to be purchased out of current funds and therefore must be purchased using capital funds. (See footnote 24.)

Academic Doctoral Scientists and Engineers

This section examines major trends over the 1973–97 period regarding the composition of the academic science and engineering (S&E) workforce, its primary activities (teaching vis-à-vis research), and the extent of its support by the Federal Government. For a discussion of the nature of the data used here, see sidebar, “Data Source.”

The Academic Doctoral Science and Engineering Workforce[25]

Employment of science and engineering doctorates exceeded 60,000 by 1961[26] and reached 215,000 by 1973. Since 1973, the number has more than doubled, reaching 505,200 in 1997—a 135 percent increase. (See chapter 3, “Science and Engineering Workforce.”) Over the 1973–97 period, the academic employment component increased from an estimated 118,000 to 232,500—a rise of 97 percent.[27] (See appendix table 6-19.) Consequently, the academic employment share declined over the period from an estimated 55 percent

[25]The academic doctoral science and engineering workforce includes full, associate, and assistant professors and instructors—defined throughout this section as faculty—lecturers, adjunct faculty, research and teaching associates, administrators, and postdoctorates.

[26]NSF (1964).

[27]The trend data in this section refer to scientists and engineers with doctorates from U.S. institutions, regardless of their citizenship status. Comparable long-term trend data for Ph.D.-level scientists and engineers with degrees from non-U.S. institutions are not available. A 1993 U.S. Department of Education survey of academic faculty suggests that this component of the academic workforce numbers around 13,000. An estimate derived from NSF’s National Survey of College Graduates, based on the 1990 Census, puts the number at about 21,000. The higher estimate (which includes postdoctorates not necessarily covered by the Department of Education’s survey) is likely to more closely reflect the definitions used in this chapter.